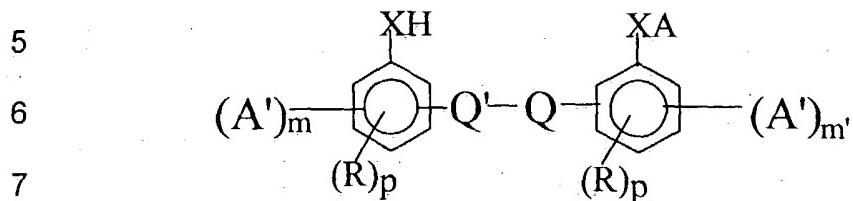


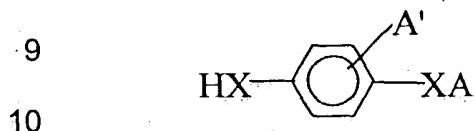
1 1. A phosphorus-containing hardener having a formula selecting from
2 the group consisting of (a), (b), (c) and (d):

3 (a)

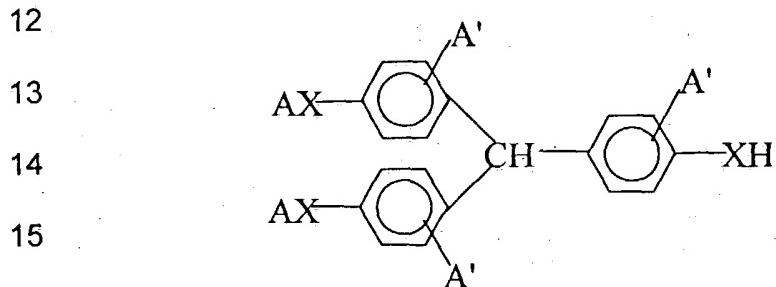
4



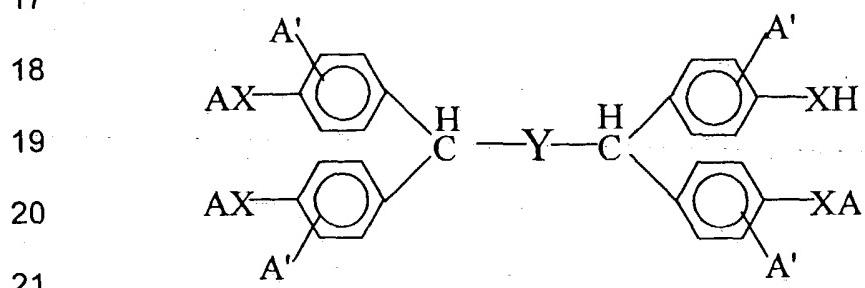
8 (b)



11 (c)



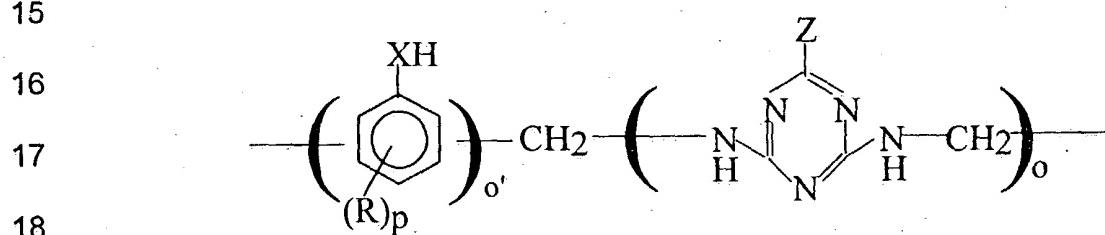
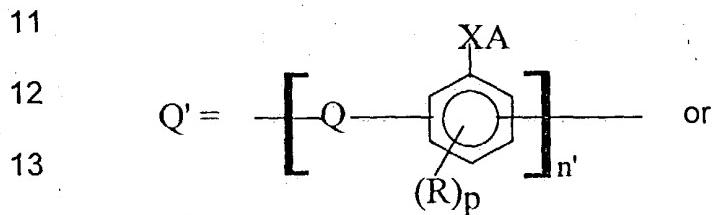
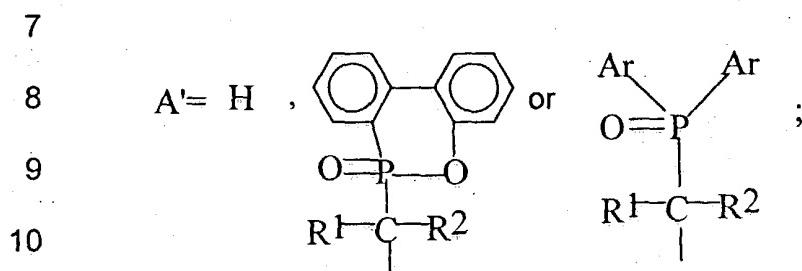
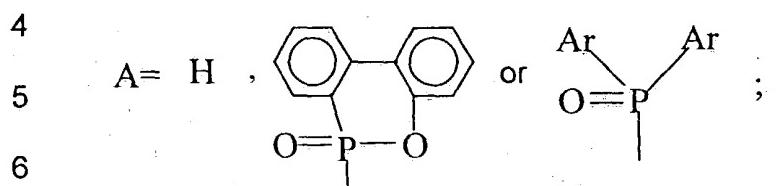
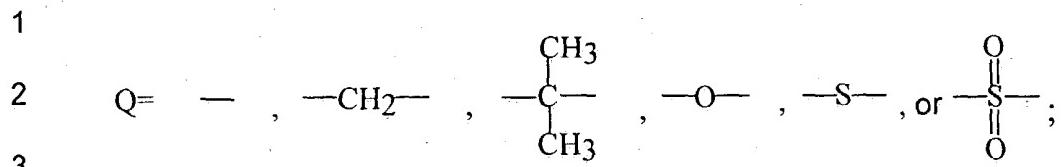
16 (d)



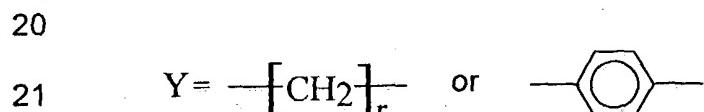
22 wherein

23 m = 1 or 2; m' = 0 or 1; p=0~3; R = C1~C4 alkyl; X = O, S or NH;

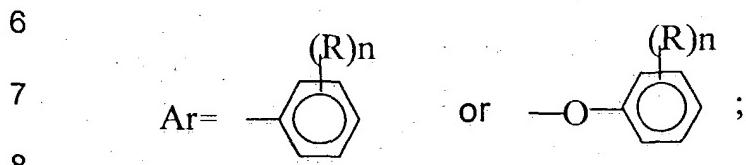
24



19 wherein $Q = -$, when Q' is the latter;
 20



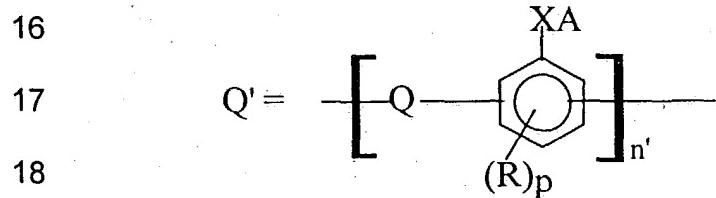
1 R¹, R² independently are H, C1~C18 alkyl, C6~C18 aryl, C6~C18
2 substituted aryl, C6~C18 aryl methylene, or C6~C18 substituted aryl
3 methylene;
4 n' = 0~11; Z = -NH₂, -NHR, or -R; o = 1~3; o' = 3~10; r = 0~6; R, Q
5 and p are defined as above;



9 wherein R and r are defined as above;
10 wherein either all the A or A' in each formula of (a) to (d) are H, and at least
11 one of the A is not H when all the A' are H in each formula of (a) to (d), and
12 at least one of the A' is not H when all the A are H in each formula of (a) to
13 (d).

14

15 2. The hardener according to claim 1, wherein all the A' are H, and



20 3. The hardener according to claim 2, wherein said hardener has a
21 structure of the formula (a).

22

23 4. The hardener according to claim 1, wherein said hardener has a
24 structure of the formula (b), and all the A' are H.

1 5. The hardener according to claim 1, wherein said hardener has a
2 structure of the formula (c), and all the A' are H.

3

4 6. The hardener according to claim 1, wherein said hardener has a
5 structure of the formula (d), and all the A' are H.

6

7 7. The hardener according to claim 3, wherein p is 0.

8

9 8. The hardener according to claim 3, wherein X is -O- or -NH-.

10

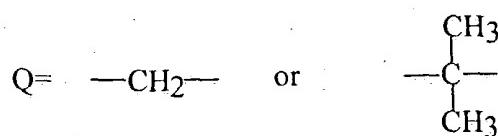
11 9. The hardener according to claim 3, wherein R is methyl.

12

13 10. The hardener according to claim 3, wherein

14

15



16

17 11. The hardener according to claim 3, wherein only one A is not H in all
18 the A.

19

20 12. The hardener according to claim 3, wherein

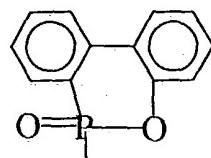
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A =



1 19. The hardener according to claim 18, wherein n is 0.

2

3 20. The hardener according to claim 5, wherein X is -O-.

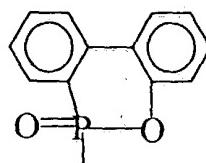
4

5 21. The hardener according to claim 5, wherein only one A is not H in all
6 the A.

7

8 22. The hardener according to claim 5, wherein

9 A=



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11

12

13 23. The hardener according to claim 5, wherein

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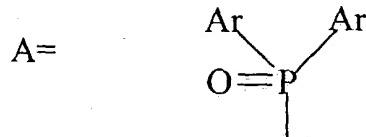
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15 , wherein Ar is defined the same as in

16 claim 1.

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24 24. The hardener according to claim 23, wherein n is 0.

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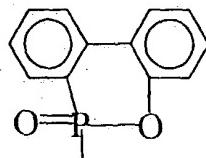
34

35 25. The hardener according to claim 6, wherein X is -O-.

36 26. The hardener according to claim 6, wherein only one A is not H in all
37 the A.

1 27. The hardener according to claim 6, wherein

2 A=

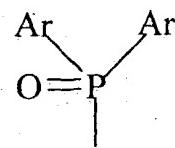


5

6 28. The hardener according to claim 6, wherein

7

8 A=



9

, wherein Ar is defined the same as in

10 claim 1.

11

12 29. The hardener according to claim 28, wherein n is 0.

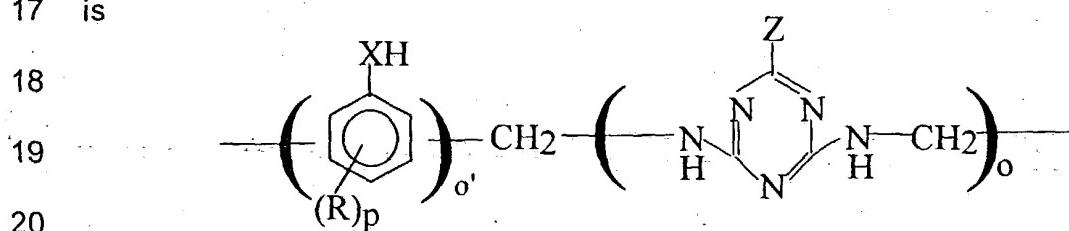
13

14 30. The hardener according to claim 6, wherein Y = —.

15

16 31. The hardener according to claim 1, wherein all the A are H, and Q'

17 is



21

22 32. The hardener according to claim 31, wherein said hardener has a

23 structure of the formula (a).

24

1 33. The hardener according to claim 1, wherein said hardener has a
2 structure of the formula (b) and all the A are H.

3

4 34. The hardener according to claim 1, wherein said hardener has a
5 structure of the formula (c) and all the A are H.

6

7 35. The hardener according to claim 1, wherein said hardener has a
8 structure of the formula (d) and all the A are H.

9

10 36. The hardener according to claim 32, wherein p is 0.

11

12 37. The hardener according to claim 32, wherein X is -O-.

13

14 38. The hardener according to claim 32, wherein R is methyl.

15

16 39. The hardener according to claim 32, wherein Z is -NH₂.

17

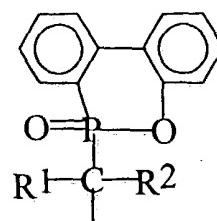
18 40. The hardener according to claim 32, wherein only one A' is not H in
19 all the A'.

20

21 41. The hardener according to claim 32, wherein

22

A'=

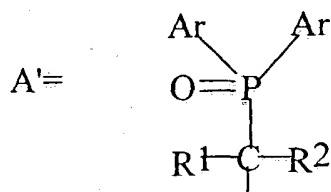


1 wherein R^1 and R^2 are defined the same as in claim 1.

2

3 42. The hardener according to claim 32, wherein

4



5 A = O=P
 6 |
 R¹-C-R² , wherein R¹, R² and Ar are defined

7 the same as in claim 1.

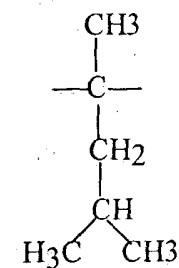
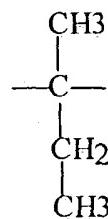
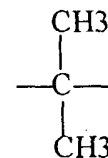
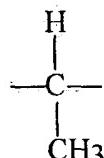
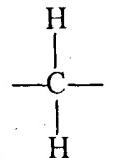
8

9 43. The hardener according to claim 42, wherein n is 0.

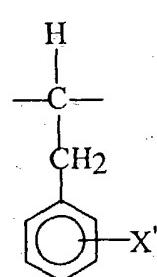
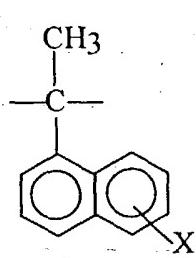
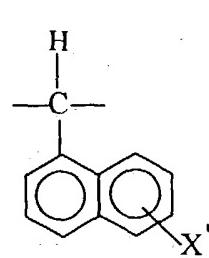
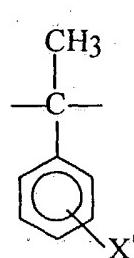
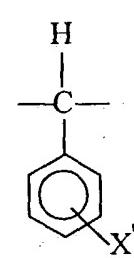
10

11 44. The hardener according to claim 31, wherein R^1 -C- R^2 is

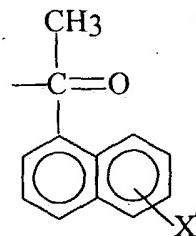
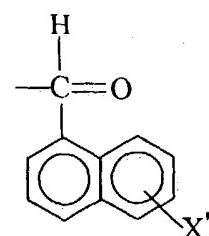
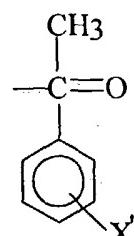
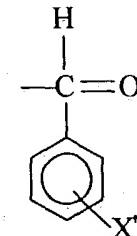
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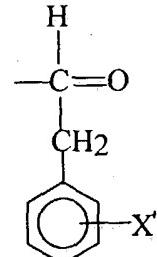
16



20



on



1 wherein X' = H or halogen.

2

3 45. The hardener according to claim 44, wherein X' = H or halogen.

4

5 46. The hardener according to claim 31, wherein R¹ and R² are
6 hydrogen.

7

8 47. The hardener according to claim 33, wherein X is -NH-.

9

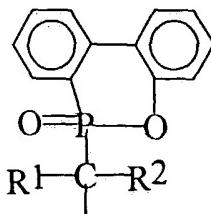
10 48. The hardener according to claim 33, wherein only one A' is not H in
11 all the A'.

12

13 49. The hardener according to claim 33, wherein

14

A'=



15

16

17 wherein R¹ and R² are defined the same as in claim 1.

18

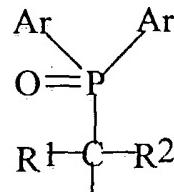
19 50. The hardener according to claim 33, wherein

20

21

22

A'=



, wherein R¹, R² and Ar are defined

23 the same as in claim 1.

24

1 51. The hardener according to claim 50, wherein n is 0.

2

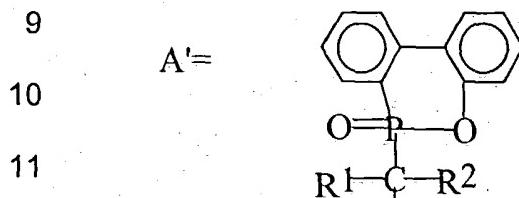
3 52. The hardener according to claim 34, wherein X is -O-.

4

5 53. The hardener according to claim 34, wherein only one A' is not H in
6 all the A'.

7

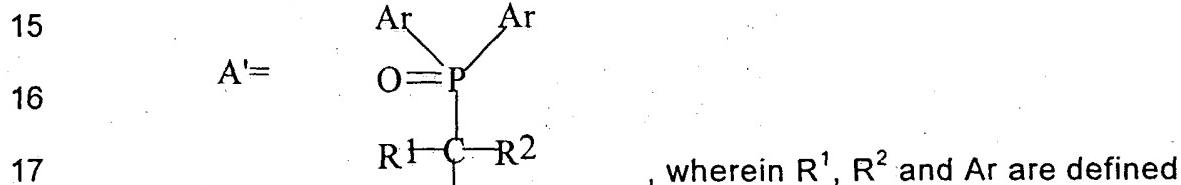
8 54. The hardener according to claim 34, wherein



12 wherein R¹ and R² are defined the same as in claim 1..

13

14 55. The hardener according to claim 34, wherein



18 the same as in claim 1.

19

20 56. The hardener according to claim 34, wherein n is 0.

21

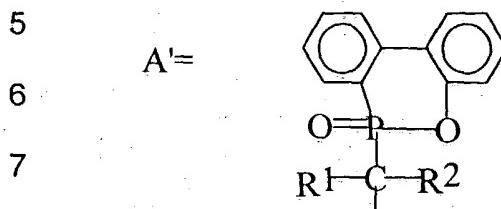
22 57. The hardener according to claim 35, wherein X is -O-.

23

1 58. The hardener according to claim 35, wherein only one A' is not H in
2 all the A'.

3

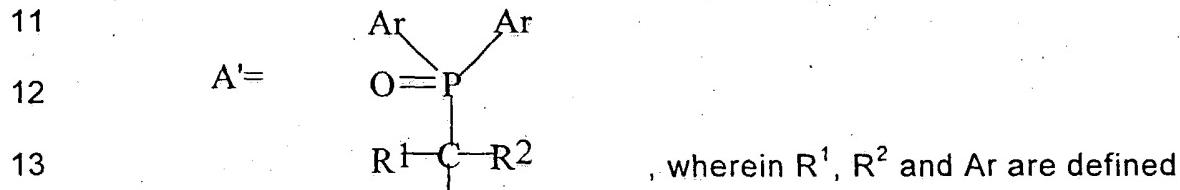
4 59. The hardener according to claim 35, wherein



8 wherein R¹ and R² are defined the same as in claim 1.

9

10 60. The hardener according to claim 35, wherein



14 the same as in claim 1.

15

16 61. The hardener according to claim 60, wherein n is 0.

17

18 62. The hardener according to claim 35, wherein Y = —.

19

20 63. A cured phosphorus-containing epoxy resin prepared by cross-
21 linking an epoxy resin or an advanced epoxy resin in a molten state of said
22 epoxy resin or said advanced epoxy resin and in the presence of a
23 hardener according to any one of claims 1 to 62 or a hardener mixture

1 comprising a hardener according to any one of claims 1 to 62 and an
2 additional hardener for epoxy resin.

3

4 64. The cured phosphorus-containing epoxy resin according to claim 63
5 having 0.5-30% of phosphorus based on the weight of the cured
6 phosphorus-containing epoxy resin.

7

8 65. The cured phosphorus-containing epoxy resin according to claim 64
9 having 0.5-5% of phosphorus based on the weight of the cured
10 phosphorus-containing epoxy resin.

11

12 66. The cured phosphorus-containing epoxy resin according to claim 63,
13 wherein said epoxy resin is a bi-functional epoxy resin selected from the
14 group consisting of bisphenol A, bisphenol F, bisphenol S, and biphenol; a
15 multi-functional epoxy resin of phenol formaldehyde novolac epoxy or
16 cresol formaldehyde novolac epoxy; or a mixture of the bi-functional epoxy
17 resin and the multi-functional epoxy resin.